“DEVELOPMENT OF SOFTWARE TO GRAPHIC IN 3D FURNITURE”
Help System to Design a type of Chair and its Variants for Educational Equipment

Walter Héctor Gonzales Arnao
National University of Engineering

ABSTRACT

The evolution of the **drawing tools and computer-aided design** (CADD), used by engineers, architects and designers have incorporated 2D, 3D, animation, simulation, manufacturing, artificial intelligence, etc. In commercially known software (CADD), the designer enters numeric data to geometrize the design; this technical information is standardized, which is a problem if you want to customize a piece of furniture (chair, bench, etc.) for children and permanent or temporary disabled people, whose measures enable a healthy posture. The problem is that not everybody handles this ergonomic technique with human biometric data for use in furniture. The use of standardized measures in furniture is the major cause of injuries and pathologies detected at very early ages, due to pathogenic positions held by long hours in furniture that does not correspond to the average size. The text presents the results and development of a web-based software that geometrizes (2D, 3D) for manufacturing furniture, ergonomically designed for a user with just entering a size or a captured photo, the system gives you complementary technical report highly specialized, becoming the software tool for design furniture designer to reduce time in the design process.

Keywords
Software, web, furniture design, ergonomics
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1. INTRODUCTION

Designing chairs with trade measures is difficult and designing custom ergonomic chairs is a more complex task. Among other reasons because a custom ergonomic design has to consider the particular user's biometric and usually performed by experienced designers; the design of commercial chairs has to be general enough to serve everyone but there are problems when the user does not have the average size which is the case of the Peruvian man. A young designer who starts to design ergonomic furniture, will take some time to start from scratch to be documented in libraries and consult experts also has to make some projects to acquire this expertise.

The "Support System for Designing a type of chair and its variants for Educational Equipment" (hereinafter refer to as SWDOU system) is a software that allows a designer started, get personalized ergonomic measures of 2D, 3D furniture and a technical report in real time from the PC internet, mobile, etc. with only with just entering the size of the user at this stage and a second stage with a photo captured by various means including manufacturing drawings. This software is part of a research carried out at the National University of Engineering, located in the first phase of development and constitutes a furniture design tool for students of UNI.

2. THEORETICAL FRAMEWORK

The methodological approach to furniture design at Peruvian universities is heterogeneous, but all have a common denominator that is investigating the state of the art to be useful in the design process; it is in this area that there is no software developed in Peru, incorporating custom ergonomic variable as well as a technical report. On the other hand, commercially known software do not provide personalized ergonomic variable because they work with standardized measures and recent research in this regard are closed source software. In this sense the software has been developed from scratch, defining structured flowchart algorithm source code for web environment.

3. METHODOLOGY

Development of software posed methodological problems from the point of view of industrial design and software engineering that for the purposes of research we use traditional and modern techniques that we adapt the needs of the project, which we explain further down.

3.1 Scope of design

The research used the axiological method according to Gojman Marcos and Robert S. Hartman approach, both professors at the School of Industrial Design UNAM, to define the variables used in the form (furniture type, material, type of user and measures); these variables are the intrinsic value, which for purposes of this research have been developed in a first stage. In future research the extrinsic and systemic values can be incorporated into the software, which are the pillars of this axiological method.
Furthermore it should be noted that to solve the problem of the form Robert S. Hartman's axiology was used, which is based on an axiom: "good is something that meets its definition"; in this sense the form of software poses defining the furniture, to establish the characteristics that will define the furniture.

3.2 Software Scope

To carry out this research, two methodological parameters, that provide us divergent views developing quantitative and qualitative methodological strategies, which we explain below arose:

3.2.1 Quantitative Methodology

This quantitative methodology is based on the development of software engineering that is the framework used to structure, plan, and control the development process in information systems.
For software development in this research the model Top-down ('top-down') was used; because each project has its uniqueness, this model has been adapted by the following steps:

I. Define the project. II. Context analysis. III. Requirements definition. IV. Preliminary design. V. Detailed design.

3.2.2 Qualitative Methodology

The draft qualitative methodology is based on web interface graphic user environment. Usually user actions are performed by manipulating the graphical environment web (form).
Usually user actions are performed by manipulating the graphical environment web (form).
The web graphical environment is everything visual (design) that gives us the best of the software and is related to the habits of Internet users. For the present project web graphics environments have been taken into account empirically that resemble the proposal and focus on the impact of users according to our sensibilities.
For further research it will be required a specialized study of habits of web graphical environment users, so that the software will take effect on users and the life cycle is greater.

4. PROBLEM APPROACH

In the approach of the initial problem the following points were considered.

4.1 Basic Information

4.1.1 Consideration was entering biometric data in a form or other form of information access. These data can be typed manually or via an image that is then sized. Here I mean basically enter a person's height and length from knee to foot.
(These dimensions may be entered in a template of the human body)

4.1.2 With these data I shall dimension basic furniture (bench)

4.1.3 Data on the dimensions of the bench will be obtained from a mathematical calculation that involves ergonomic relationships (human dimensions)

4.1.4 The chair is a fixed 3D and 2D template. In which the calculations on corresponding sides are shown in Figure 1.

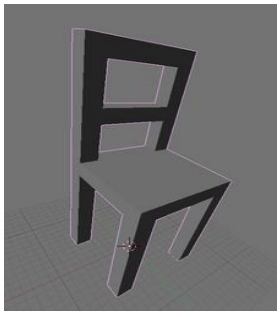


Figure 1: 3D chair drawn in OpenGL (Reference taken from http://booki.flossmanuals.net)

4.1.5 At some point also, with the initial

data, it can be contrasted with a predefined 3D.

4.1.6 With the result shown in section 4 (bench) a template will be shown, predefined and fixed, with the most complete data and additional constant splicing measures.

4.1.7 It is proposed to use the software support to the data shown in the following technical details:
Language: C + +
Libraries: Qt, OpenGL (free software)
Platforms: Windows, Linux (if required in the second phase of software).

4.2 Design of Interface between SWDUO System and the Graphing
The interface design is the development of a system that allows a user to help take body measurements and through these, restore custom settings seats which he must use, as well as a 3D drawing of a chair with the right proportions for that person for viewing.
The system to be developed consists of four parts:
4.2.1. Acquisition of basic data: the user will choose an alternative between a questionnaire saved in a database of the SWDOU system figure 2, (giving him the necessary facilities, such as the use of a tutorial see figure 3). In that tab you should see all the information on quantitative technique

Figure 2: Page of the DOU system http://swdou.site40.net/SP/index.html, which will be used as basis to start system development

Figure 3: The Dou system has a video tutorial in the main screenshot http://swdou.site40.net/SP/index.html#, to visualize to use the system.

4.2.2 Decision-assisted measures: then proceed to instruct the user which steps to take:
4.2.2.1 Measurement of the reference object: the user helped with the mouse will select the ends of the reference object and will introduce its measure into a box (the possibility that the measure of the stature of the reference subject is contemplated).
4.2.2.2 Measurement of body parts: the user helped with the mouse will select his extremities in the photo (instructions will appear on screen that seeks to measure a specific body part, and an exemplifying graph), in the second phase of the project.

Note: an alternative process is going to be programmed to steps 4.2.2.1 and 4.2.2.2 for users who prefer to take body measurements using a tape measure (for more precise parameters of the bench)

4.2.2.3 Calculation of the parameters of the chair: Based on ergonomic criteria parameters of the chair are calculated (height, width, depth, etc.).

4.2.2.4 Parametric drawing of the Chair: Based on the parameters of the chair the software makes a 3D drawing of this, so that the user can view its proportions (the user will be able to rotate and scale it to see it better)

4.2.2.5 For a better understanding a flow chart has been developed for explaining the operation of the logic Interface to guide the programmer in this first stage, see figure 4.

TABLE 1 defined parameters in the dou system		
Parameter	Symbol	description
Height of the seat	A	Distance from the sole and the free space between the back zone of legs and the front part of the seat
Effective depth of the seat	C	Distance between the back zone of legs and the front of the seat and the sacral zone
Minimum backing width	F	It is set by default
Total height of backrest	G2max -G2min	It is set by default. Minimum - maximum
Seat height to the base of support	E	It is set by default
Radio on the front edge of the seat	r1	It is set by default
Minimum radius support	r2	It is set by default
Seat angle	δ	It is set by default
Backrest angle	ß	It is set by default
Mínimum width of the seat	D	It is set by default
Height	H/M	Size

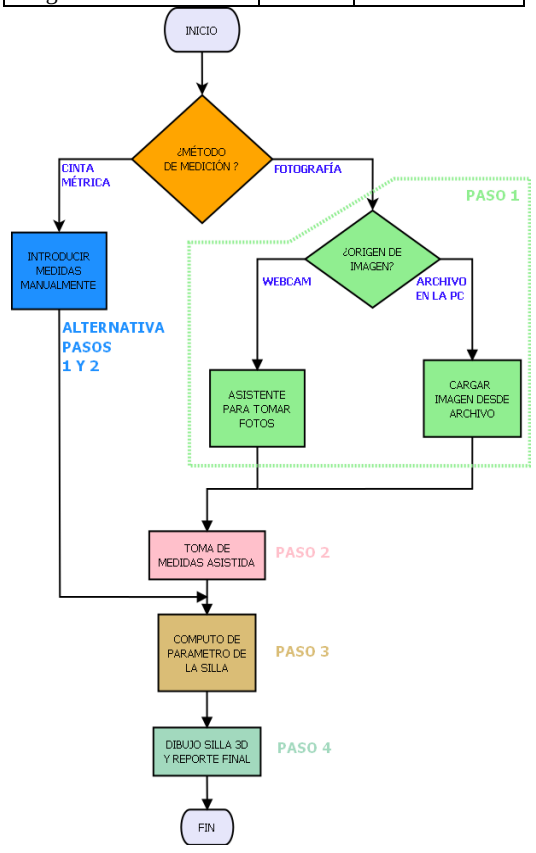


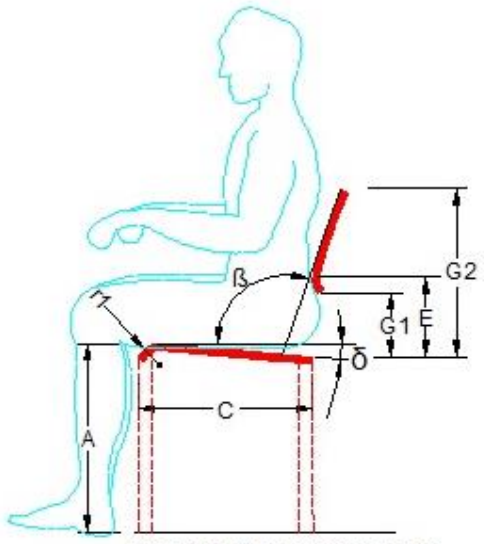
Figure 4: Flowchart approach to the problem

5. CONSTRUCTION PARAMETERS TABLE OF SWDOU SYSTEM

"Building the parameter table" is defined see Table 1 and Figure 5 as the ordered set of process steps to follow in order to get to the identification of data to be entered to SWDOU system (application) in this particular case, to achieve furniture dimensioning.

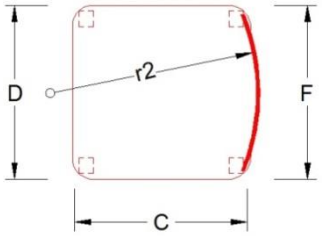
The process of creating or identifying parameter for the software can be very complex, depending on its size, and criticality characteristics thereof. For example the creation or identification of the furniture parameters in this part of the research project, we rely on the NATIONAL TECHNICAL STANDARD, SCHOOL FURNITURE, ITINTEC 260 008, PERUVIAN TECHNICAL STANDARD, NTP 260.026/2005 and Manual for design and manufacturing furniture for different educational levels. (See bibliography).

Table 1: you can display the main parameters that make up the design of a chair where we have selected the most relevant, so are usually divided into three categories according to their parameter type (A, C and H / M).



DIMENSIONES EN SECCION

DIMENSIONS IN SECTION



DIMENSIONES EN PLANTA

DIMENSIONS IN PLANT

Figure 6: In both figures, both in the section as shown on the plant, the minimum dimensions to be used when designing a chair; whose values are admitted directly and some others are placed by the software by default.

5.1 References in web environment considered in the SWDOU system.

There are several methodologies for introducing this parameter (A, C and H/M) at the application or software, one of the most popular is the interface system that provides the software (program) that exists in the web; entrance windows as in Figure 7,

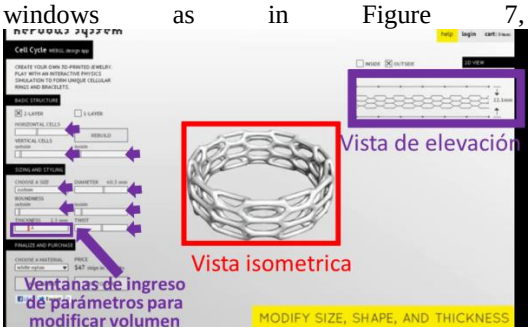


Figure 7: Parametric application screenshots in jewelry, with the data table to manipulate. This input parameters method allows fast calculation in the software and provides an approximation of all the possibilities of three-dimensional geometry of figures 8, 9 and 10 shown in the isometric production costs in a "software project" (relationship man/hours, monetary cost, number of source lines according to language used, etc.).

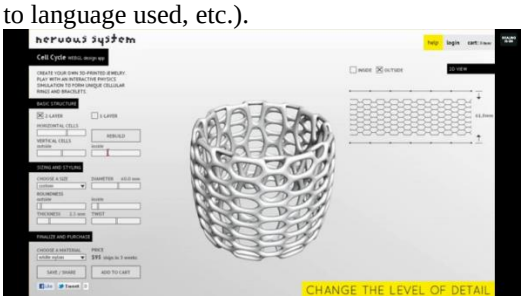


Figure 8: result of manipulation by entering random data

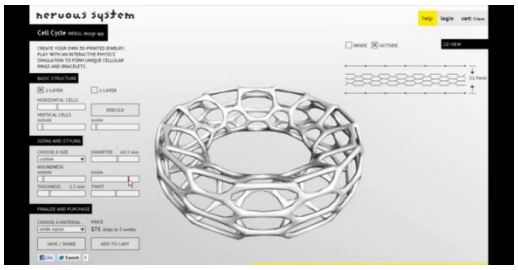


Figure 9: other alternatives in 3D geometry

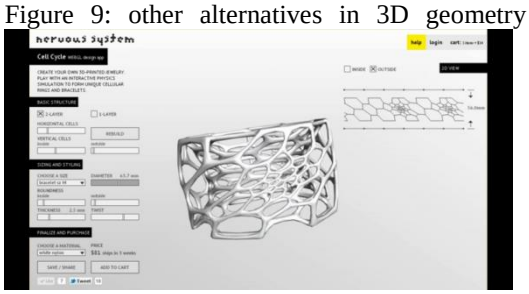


Figure 10: 3D view rotated for convenience of users, the nervous system software is web-based, closed-source commercial purposes.

Considering the versatility of this software nervous system, which can be viewed on this site:
http://n-e-r-v-o-u-s.com/cellCycle/
http://n-e-r-v-o-u-s.com/tools/
~~http://n-e-r-v-o-u-~~
s.com/shop/product.php?code=4

In Figures 8, 9 and 10 you can see the versatility of the software where the parameters are modified to obtain geometries after changing the parameters given by the program and can be summarized of technical specifications in Table 2.

TABLE 2 Program in Web: Nervous System	
Technologies used	WebGL, ProcessingJS, GLSL
Original versión: URL	2009-07-08 http://n-e-r-v-o-u-
Last version	2012-03-09
Celular Cycle is design application based	Cell design for 3d-printing Web site for creating 3d models printable cells.
performance	It can form, twist and subdivide, transforming a simple mesh to a complex patterned structure.
application	It is a dynamic physible SOFTWARE. You can make jewelry, lampshades, sculptures, whatever you want, all in the browser.

Table 2: you can appreciate the technical property of the application that is used in web, the only interacting with the user as the search was conducted.

5.2 Classification of utilitarian objects according to common characteristics.

For this project it was considered as "commercial items", the furniture set applying software which is the target of this development research; by affinity it was decided that the chair and the bench apply to this category of common characteristic.

Chair and bench were considered because they have common features in their functionality and their relationship with the user; subsequently it will serve to simplify the final report making minor modifications.

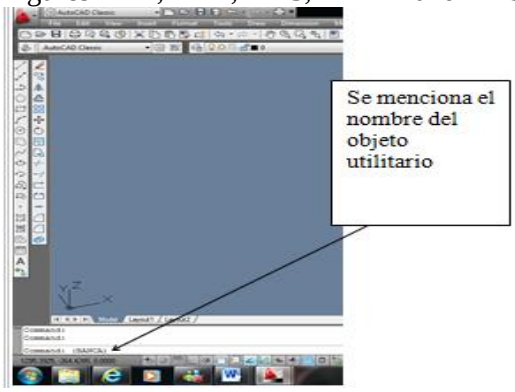
6. CONSTRUCTION OF 3D GRAPHING FOR THE SWDOU system

6.1 AutoCAD Grapher

It turns out that at present there has not been plotting using AutoCAD from the Web as the AutoCAD requires many memory resources.

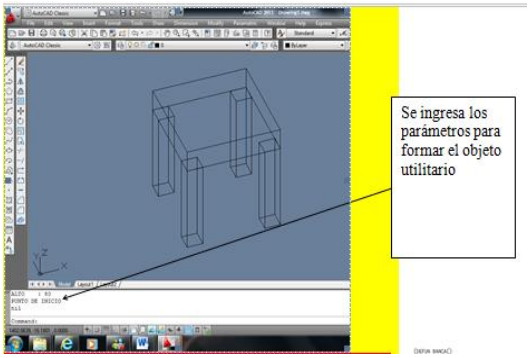
In the proposal parameters are stored representing utility objects (movable) according to common characteristics structured in database software algorithms; these can be geometrized using a program on the user's PC.

The camming of furniture using Autolisp, is shown below as an introduction to the geometrization of utilitarian objects. See Figures 11, 12, 13, 14 and 15



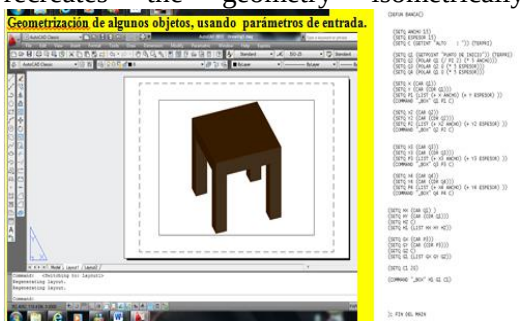
The name of utilitarian object is mentioned

Figure 11: in AutoCAD you can enter parameters assigning a matching rule.



Parameters are entered to form the utilitarian object

Figure 12: These parameters can be generated in a 3D virtual space that recreates the geometry isometrically



Geometrization of some objects, using entry parameters

Figure 13: textures are another feature that can be placed, all within the graphical environment AutoCAD, which you cannot access the source code.

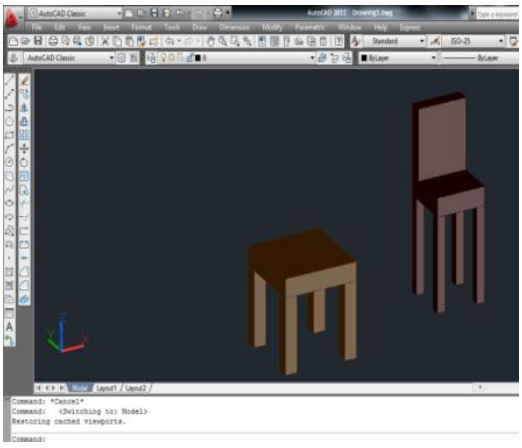
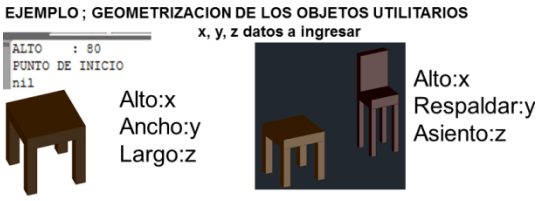


Figure 14: Graphical representation of AutoCAD 3D is of good quality, and alternative access to a parametric model, in this environment represents a difficulty that prevents work it in a web environment, since it is a license that would be incurred, being of inaccessible use in the project, with the drawback that there is no access to the source code.



EXAMPLE; GEOMETRIZATION OF UTILITARY OBJECTS

x, y, z data to enter

HEIGHT **: 80**
START POINT
thousand

Height: x	**Height: x**
Width: y	**Back: y**
Length:	**Seat: z**

Figure 15: Variables that AutoCAD offers, are the first approach to the parameters design.

Figures 11, 12, 13, 14 and 15 show that the construction of the geometrization or so called 3d uprising is theoretically feasible.

6.2 Graficador webGL

This tool was chosen because it allows you to display 3D graphics and use OpenGL graphics libraries for different Web browsers.

The WebGL (the javascript library where the plotter is written on) supports reading files format ".OBJ" (a drawing file that can be generated by different CAD software). BLENDER software was chosen to assist in the drawing of the furniture in question (it is clear that this is only part of software development and will NOT be required by the user in the final version of the website). In the Blender environment some furniture have been drawn (see Figure 14), such furniture that are currently being developed to display those furniture directly on the chart that was written for this project.

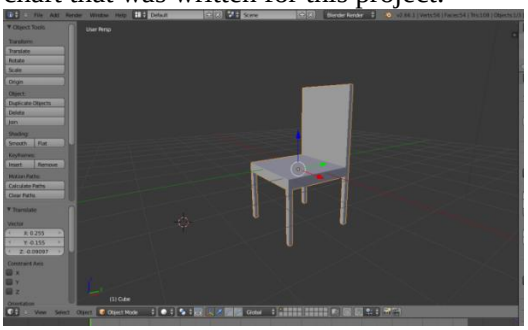


Figure 14: Chair drawn in 3D with Blender, which is being worked to export it to the website being developed.

6.2.1 Development and implementation of measures to SWDOU system

Regarding the 3D furniture plotter the possibility to modify furniture measures parametrically and interactively was explored (from the same browser), to better understand this, see Figure 15 and 16:

Furniture measurements:
Measurements:
X 00
X 00
2 03

Figure 15: Screenshot of 3D plotter, which displays a table that allows modification of measures allowing implementing measures

Furniture measurements

Figure 16: Screenshot of 3D plotter having introduced different measures.

6.2.1 Development and Application of Textures to Dou system.

We have tried this texture environment 360º that is used to wrap the 3D scene, but have not been implemented in the SWDOU system at this stage of development, and can be given different textures to furniture plotted using WebGL environment. To appreciate this point, see figures 17 and 18:

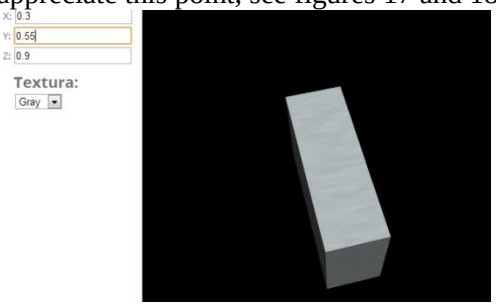


Figure 17: Image loaded with a grey texture using Blender environment.

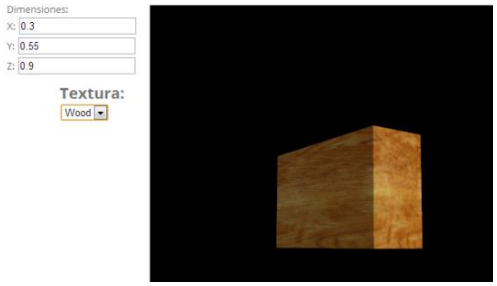


Figure 18: 3D Graphic of a piece of furniture in wood texture using Blender environment.

7 FINAL RESULT

The final result can be displayed on the website, which is in the stage of purification, i.e. is correcting errors and is summarized in Table 3.

TABLE 3 Program in Web: SWDOU system	
technologies	WebGL, ProcessingJS, GLSL, Blender
original version:	2013-07-15 URLhttp://swdou.comuv.com/ http:// **swdou.site40.net**
tutorial	http://www.youtube.com/watch?v=npALZ85gNNQ
Source code	1 <!DOCTYPE html> 2 <html lang="en"> 3<head> 4<title>GraficadorSWDOU</title> 5<meta charset="utf-8"> Continue seeing source code in web
Benefits	Allows displaying 3D graphics plus technical report in web browsers, of a piece of furniture
Application	You can make chairs, seats, personalized ergonomic products with just entering the size in the browser. (Android devices)

Table 3: you can appreciate the technical characteristic of the SWDOU system used in web.

7.1 How to enter SWDOU system.
Proper browser opens to run, and can be: Google Chrome, Mozilla Firefox, Opera, etc.

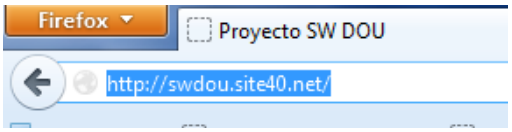


Figure 19: Submitting web address in the browser Mozilla Firefox, for example.

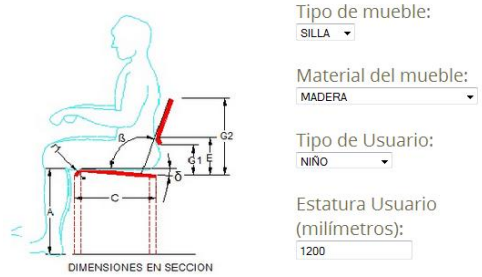
7.1 Browse the website.
You will notice that it has a version in English, Castilian.

"SW DOU RESEARCH PROJECT"
Figure 20: Exploring Web site

7.1.2 Display the plotter in the menu.
Click on the section of the plotter

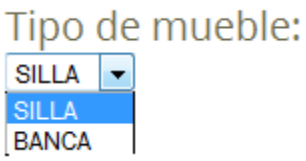
Research Institute of the Faculty of Architecture, Urbanism and Arts
Figure 21: Click in the graphic area

7.1.3 After cutting plotter the form appears, with four fields to fill



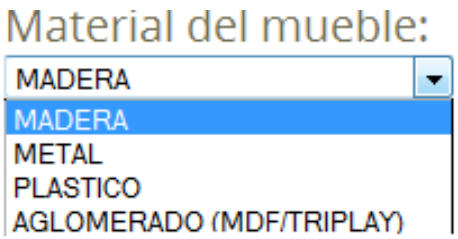
Furniture type: CHAIR
Furniture material: WOOD
User type: CHILD
User height (milimeters): 1200
Figure 22: Form for grapher

7.1.3.1 First field: Type of Furniture to Design (2 options: CHAIR and BENCH)



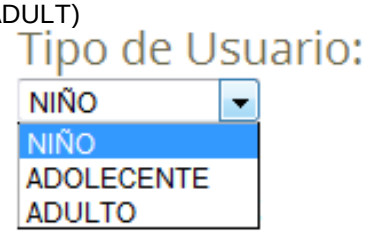
Type of Furniture
CHAIR
CHAIR
BENCH
Figure 23: Type of furniture

7.1.3.2 Second field: Material of Furniture to design (4 options: WOOD, METAL, PLASTIC and TRIPLAY)



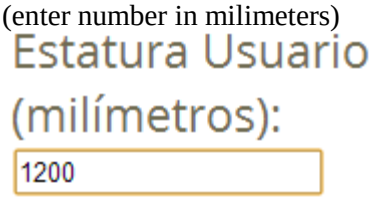
FURNITURE MATERIAL:
WOOD
WOOD
METAL
PLASTIC
AGGLOMERATED (MDF/TRIPLAY)
Figure 24: Furniture material

7.1.3.3 Third field: User type of Furniture (3 options: CHILD, ADOLESCENT AND ADULT)



USER TYPE:
CHILD
CHILD
ADOLESCENT
ADULT
Figure 25: User type

7.1.3.4 Fourth field: Furniture User Height (enter number in milimeters)



User Height
(milimeters):
1200
Figure 26: User Height

7.1.4 Press the "Securities sure to set" button and display the 3D sketch and drawings and design criteria for the desired furniture.

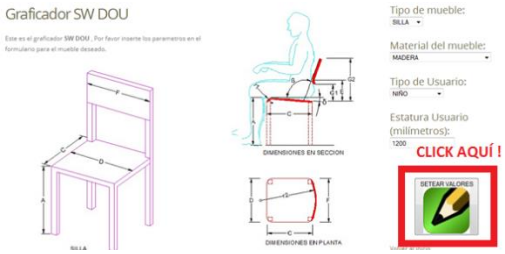


Figure 26: Pressing Setting Values Button

7.1.5 Visualization plotting by the DOU system

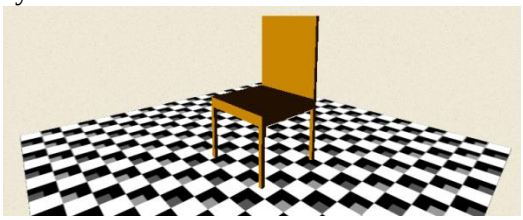
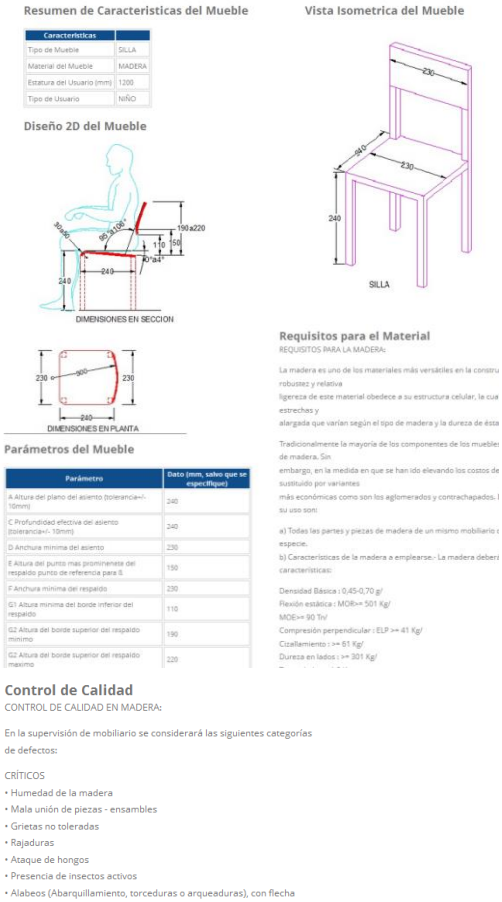


Figure 27: Visualizing Sketch 3D (bottom of web page)

7.1.6 Visualization of technical report

It consists of two technical charts, isometrics and drawings with measurements to manufacture, finally material requirements and recommendations for quality control in manufacturing.



Summary of furniture characteristics
2D Furniture design
Isometric furniture view
Dimensions
Isometric furniture view
Requirements for material
Furniture parameters
Requisites for material
Quality control
WOOD QUALITY CONTROL

Figure 28: Viewing Components of Technical Report (3D sketch below)

8. CONCLUSIONS

Drawing tools and computer-aided design (CADD), in Web environment, are not developed because they are not portable in web browsers and are recent technologies.
The alternative of using WebGL is quite innovative, yet has not been used this library for the objective we present (as this is fairly recent and lacks exploration).

Increased complexity of source code, which is in its final phase and meets all (3D) expected roles

The form with the piece of furniture parameters represents a great simplification for desig.

Recommendations will be given in each piece and it will have a direct bearing with the data entered in the form.
The following information should be included in the form: Age of user, type of furniture, desired material for the furniture and some additional questions provided in the form.

9. DISCUSIÓN EVALUACION

These CADD tools have a tendency to use artificial intelligence technologies, so that a computer can design by itself in the future.

The application works for all commercial browsers in the market (except Internet Explorer from Microsoft, because this one, to date, does not give support to WebGL)

There have been WebGL compatibility issues with outdated browsers cited and 3D sketch versions will not be displayed. However, all the relevant information in the technical report will be visible.

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